DISTRIBUTION OF MINUTES FOR ALPHA MAGNETIC SPECTROMETER-02 GAUSS LIMIT SPECIAL DISCUSSION MEETING ON OCTOBER 16, 2001.

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See Attachment 1 for a list of meeting attendees/ additional minutes recipients.

NASA JSC
Payload Safety Review Panel
Alpha Magnetic Spectrometer-02
Gauss Limit Special Discussion Meeting

Minutes of Meeting
October 16, 2001

1.0 INTRODUCTION

1.1 **General:** The Payload Safety Review Panel (PSRP), chaired by JSC/MA2/A. M. Larsen, met on October 16, 2001, with representatives of Alpha Magnetic Spectrometer-02, the Payload Organization (PO), at the Regents Park III Conference Facility for an Alpha Magnetic Spectrometer-02 (AMS-02) Gauss Limit Special Discussion Meeting. JSC/NC44/A. N. Nelson, Jr., the supporting Payload Safety Engineer (PSE), introduced the meeting and attendees (see Attachment 1). JSC/NC44/S. J. Daniel provided additional PSE support of this payload.

1.2 **Background:** The AMS-02 is a Department Of Energy, NASA, and various high-energy physics institutes-funded state-of-the-art cryogenic superconductive magnet that is designed to search for anti-matter and dark matter. The AMS-02 experiment is a particle physics detector. The science objectives of the AMS-02 experiment are to search for anti-matter (anti-helium and anti-carbon) in space, to search for dark matter (90% of the missing matter in the universe) and to study astrophysics (to understand the Cosmic Ray propagation and confinement time in the galaxy). The AMS-02 experiment will utilize a Cryogenic Superconducting Magnet (Cryomag) with planes of detectors on top, inside, and below the magnet. The precursor Space Shuttle flight of AMS-01 used a permanent magnet in place of a cryomagnet. LMSO will provide analysis and design for the Cryomag Vacuum Case hardware. The superfluid helium tank has a capacity of about 2500 liters, and the cryogenic insulation system includes 160 layers of MLI superinsulation.

1.3 **Scope:** This meeting focused on determining an acceptable vent hole size in the AMS-02 Vacuum Case (VC) to preclude venting in the Orbiter payload bay (PLB) during ascent; and discussing Gauss limit increases on the Extra-Vehicular Activity (EVA) Mobility Unit (EMU), without which AMS-02 would interfere with the EMU while in adjacent translation paths. The status of Action Items (AIs) previously assigned to this payload is summarized in the table at the end of the minutes.

1.4 **Conclusion:** No agreements and no action items resulted from this meeting.

2.0 SIGNIFICANT SAFETY DISCUSSION

2.1 **Hardware Overview:** The AMS-02 hardware is made up of several subsystems, including: the Cryogenic Superconducting Magnet (Cryomag), Unique Support Sutructure-02 (USS-02), Synchrotron Radiation Detector (SRD), Transition Radiation Detector (TRD), Time-Of-Flight (TOF) Scintillator Assemblies, Ring Imaging Cherenkov Counter (RICH), Electromagnetic Calorimeter (ECAL), data and interface electronics, electrical cables, two Monitoring and Control computers (MCCs), Power Distribution Box (PDB), AMS-02 Crew Operations Post (ACOP), Thermal Control System (TCS), Micro Meteoroid and Orbital Debris (MM&OD) shields and a passive Payload Attach System (PAS). For additional details regarding the hardware, see the minutes from previous AMS-02 meetings held on January 16, 2001 and October 11, 2001.

2.2 **AMS-02 Vacuum Case Leakage:**

2.2.1 **Issue Description:** The specific hazard addressed at the October 11, 2001 meeting was the overpressurization of the payload bay during ascent. The venting would result directly from the leakage of the vacuum case and the subsequent helium vessel warm-up. AMS-02 venting analysis conservatively assumed complete loss of vacuum (LOV). The assumption was consistent with payload preference. The worst-case assumption drives the time between the start of the vacuum case leak and the time to the venting of the helium vessel. The critical time period for the AMS-02 LOV is just at launch (T-0) and/or shortly after. The most critical time period for AMS-02 venting into the Payload Bay is between T+30 and T+60 seconds.

The original vacuum case leakage analyses indicated that the critical time period for AMS-02 LOV was at ~T-190 to ~T-120 seconds. The Phase 0/I safety review hazard control approach included the following:

- Qualification and acceptance testing of the AMS-02 structural test article and flight unit;
- Independent leak testing of each flight unit o-ring during acceptance testing;
- Monitoring the flight unit vacuum case in final configuration for weeks/months prior to launch up until T-31 seconds. Monitoring changed to up until T-9 minutes as a result of the PSRP review. The monitoring details are To Be Determined (TBD).

Delaying the potential venting of the dewar beyond the critical Orbiter ascent period by incorporating a cryogenic insulation around the helium vessel was investigated by AMS-02. The results indicated the following: the amount of insulation needed to eliminate LOV concern would reduce the on-orbit life of AMS-02; the original analysis assumption for the helium vessel LOV heat load was too low; and subsequent analysis indicated that the critical time period for loss of vacuum of the AMS-02 vacuum case is no longer prior to launch, but is now at or during initial seconds of launch.

2.2.2 **AMS-02 Proposed Resolution:** AMS-02 personnel proposed what they believe is a conservative, maximum credible leak of the vacuum case to be experienced at or just prior to launch. They assumed two "hole" sizes that were presented for acceptance and subsequent testing and analysis. The hole sizes were: 3" long x 0.001" height, resulting in an equivalent orifice diameter of ~0.062" and 3" long x 0.003 height, resulting in an equivalent orifice diameter size of ~0.107". These hole sizes were considered to be highly unlikely due to the AMS-02 bolt spacing around the circumference of the AMS-02 vacuum case flanges and the expected direct contact between the o-ring flanges.

2.2.3 **AMS-02 Vacuum Case Testing:** Two AMS-02 units will be built, one flight identical Structural Test Article (STA) consisting of the STA vacuum case and a Cold Mass Replica (with STA super-fluid helium tank and a simulated mass for cryo-magnet and support structure) and the flight vacuum case, flight super-fluid helium tank, and the flight cryo-magnet.

The qualification testing performed on STA vacuum case includes:

- Proof pressure test upon delivery to NASA and prior to installation of Cold Mass Replica;
- Vacuum leak check upon delivery to NASA and prior to installation of the Cold Mass Replica;
- Proof pressure test after installation of the Cold Mass Replica;
- Vacuum leak check after installation of the Cold Mass Replica;
- High level sine-sweep test;
- Acoustic vibration test to expected levels; and
- Modal testing and static leads testing to be performed on the entire payload, including the cold mass replica, the STA vacuum case under vacuum, and mass replicas of AMS-02 experiment components.

The acceptance testing and monitoring on the flight vacuum case includes:

- Proof pressure testing prior to installation of the magnet;
- Vacuum leak check of each o-ring after installation of the cryo-magnet and all cryo-systems;
- Proof pressure testing after installation of the cryo-magnet and all cryo-systems; and
- Monitoring the vacuum case pressure and super-fluid helium tank pressure-temperature for approximately twelve (12) months up until T-9 minutes.

The PO proposed PSRP acceptance of the recommended hole size, based on the following:

- Accept proposed hole sizes since they are conservative;
- Allow AMS-02 to continue with testing and provide a new venting assessment to Space Transportation System (STS);
- If the assessment is acceptable to STS, the overpressure issue is closed;
- Full-scale emergency vent test is not required.

Subsequent to the PSRP discussing how to verify the PO's recommended approach, the PO agreed to provide the results of small-scale assessments and the rationale for them, which included the following:

- Small dewar vent test;
- The correlation between the small-scale test to the full scale system;
- The rationale for determining that the small-scale dewar test is adequate for assessing the full scale system;
- Providing these results to EP4/H. Flynn in February 2002.

Discussion then focused on the random vibration and qualification testing approach proposed by the PO. The PO maintained that no vibration testing on the Vacuum Case flight unit was necessary because the workmanship of each component was being verified as payload development progressed. Additional reasons for utilizing qualification testing instead of random vibration testing included the fact that vibration testing the entire vacuum case would not affect it due to its high insulation level and vacuum casing; plus its size, weight, and testing costs made vibration testing unfeasible. The PO offered that the straps were the only component that could conceivably be a concern, and reiterated that they were being sufficiently tested. JSC/EP4 offered that the PO should validate that the leak is not a credible risk. Following affirmation from the Structures Working Group and the Fracture Control personnel, the PSRP agreed with the PO's proposed testing approach regarding the hole sizing.

Additional discussion related to determining the best path forward in regard to the two (2) O-ring seals on the VC not meeting the requirements of NSTS 1700.7B, "Safety Policy Requirements for Payloads Using the International Space Station (ISS Addendum)," which calls for using three (3) O-rings. The PSRP identified two options available to the PO pertaining to this issue, including Design to Minimum Risk or an equivalent fault tolerance approach. The Panel maintained that Design to Minimum Risk approach that was previously chosen was not a viable option per 1700.7B. Therefore, the best option was to use the equivalent fault tolerance approach that included using two (2) O-rings along with a plethora of verification that would be equivalent to design, test, and verification. Subsequent to ensuring that the representatives from all the technical departments and directorates approved the equivalent fault tolerance approach, the PSRP accepted it and closed this discussion.

The PSRP offered that they would continually monitor the verifications for AMS-02 through the Structures Working Group, as the payload progressed step-by-step.

The Panel questioned the PO about identifying the launch criteria, with the PO offering that the issue was in work, but the numbers would be provided by Phase III.

2.3 **Gauss Limit:** The PO proposed a change request for the Gauss limit requirement from sixty-three (63) to 300 Gauss because the 63 Gauss limit was not tested. The PO offered that they anticipated a problem with the cryomagnet on AMS-02 affecting the Extra-vehicular Mobility Unit (EMU) so they had funded Gauss limit testing to be performed by Hamilton Sundstrand. AMS-02 was manifested in 1995, and the testing was requested after identifying the EMU/magnet concerns. It was coordinated through the JSC Extra-Vehicular Activity (EVA) Program Office (XA) and resulted in a preliminary report from Hamilton Sundstrand. However, an issue developed regarding funding the testing needed for a change request to be provided. Following correspondence from XA Safety regarding the Hamilton Sundstrand contract, JSC/MT2 requested that the work be put on hold until the issue could be resolved.

The PO requested the numbers for the Gauss limits since they vary according to the location in relation to the magnet. The PO also offered to establish a Keep Out Zone to prevent the magnet from affecting the EMU. The PSRP stated that their concerns also related to the magnet's effects on the adjacent payloads and the translation paths, where the Gauss rate was over 300.

The PSRP determined that they would wait until MT2 received a response from XA regarding whether Hamilton Sundstrand would provide the change request and disseminate that information to the Panel. A decision was made for the PO to proceed if XA provided a positive response. If XA provided a negative response to providing the change request, then the PSRP recommended exploring other avenues to resolve the issue. JSC/SD12 offered that one possible solution could be to avoid processing a Non-Compliance Report by creating a payload-specific response. The PSRP Chair and the XA Panel representative both accepted that option. The PSRP Chair directed the PSEs to provide a status on the Safety, Reliability, & Quality Assurance Report the following week.

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JSC/NC44/A. N. Nelson, Jr.
Payload Safety Engineer

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JSC/NC44/S. J. Taylor
Technical Writer

_____
JSC/NC44/S. J. Daniel
Payload Safety Engineer

Previous Action Item Status

AI	Action	Status
1 Assigned to: SF3/J. Bates	Continue to assess the helium venting analysis with Shuttle Integration and EP4 and develop a history of cryostat operations to determine the necessity of a Launch Commit Criteria (LCC) inside T-9 minutes to launch.	Open, due Phase II Mandatory Reviewers: PSRP
2 Assigned to: SF3/J. Bates HR: AMS-02-6	Pre-submit AMS-02 vent test data regarding TCS, warm helium supply, TRD, and the cryosystem to EP4/H. Flynn for approval; submit data to USA in April 2001 for analysis; and add results to HR AMS-02-6 for presentation at Phase II FSR.	Open, due Phase II Mandatory Reviewers: PSRP
3 Assigned to: NC55/S. Loyd HR: AMS-02-7	Provide updates regarding changes to the magnetic requirements for the EMU and peripheral equipment, and status the relevant communication between the PO and EVA Project Office/XA. (PSRP may schedule a meeting with XA and AMS-02 following review of the AI, if necessary.)	Closed 10-11-01.

Status Explanation

AI 1: Not discussed at this meeting.

AI 2: Not discussed at this meeting.

AI 3: Closed at October 11, 2001 meeting because Ms. Loyd provided the updates to the PO and the EVA Project Office/XA.

There were no AIs assigned to this payload at this meeting.

ATTACHMENT 1

Payload Safety Review Attendance Log

Payload: AMS-02 Gauss Limit Special Discussion Meeting

Meeting Date: October 16, 2001

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